Community-Based Research and Development (R&D) patterns in the Water Supply and Sanitation (WSS) Sector

Pablo Catalan

***Abstract*—I explore patterns in regard to community based Research and Development in the Water Supply and Sanitation sector. I set a bibliometric analysis, covering the 1998-2008 period, by means of applying a framework based on three factors: productivity, collaboration, and research topics, which are analyzed at global and country level. Results show: a) Northern countries are the most productive ones; b) though not significant as it should, North-South collaboration is increasing; and c) Southern concerns do not represent a major share of Northern R&D, though an upward is noted.**

***Index Terms*—water supply, sanitation, community, bibliometrics**

I. Introduction

Nowadays, 1.1 billion people lack access to safe drinking water, whereas 2.6 billion still have non access to basic sanitation. Health, poverty, and gender impacts are aggravating. Just in terms of health, non-access to safe drinking water have paved the way for waterborne diseases' rapid spread affecting already half of developing nations' population: every year 1.6 million people, including daily over 3,900 children, die for want of adequate water supply, sanitation, and hygiene [1]. On the other hand, people with non-WSS do have more trouble to go out of poverty: as those ones in sickness are not up to work, local economies face manpower shortages and high health costs, thus postponing economic development. For instance, every year in India, 73 million working days are lost to water-borne diseases at a $600 million cost in terms of medical treatment and lost production [1]. Even more, however local entrepreneurs wish to start off their own small agricultural business, they may not be able to do so as local services do not provide them with the amount of water needed to. Gender gap comes up as a social hurdle to overcome. Women are those in charge of fetching water by either waiting in line in urban settlements or walking hours in rural areas. Non access to safe and close water supply exposes women's health to biologically/chemically polluted water sources and keeps them from attending school on a regular base decreasing their productivity and income-generating capacity.

International discussions on what are the causes of such crisis and how to address them have been on for a non-short period of time. Reference [2] points to a current end-users and policy-makers/high-skill professionals disconnect resulting in failing WSS solutions. Whereas the latter mostly located in wealthier nations are set to achieve Millennium Development Goals (MDGs) by working on cutting edge technologies, the former demand "simpler" solutions enabling them to cope with dignity, access, and income challenges. As local requirements must be part of the picture, the WSS sector is not good ground for "one size fits all" solutions, so that promoting bottom-up-community-based approaches to generate locally-oriented innovative solutions becomes an option worth to work on.

The article explores how the international community is addressing the challenge of Water Supply and Sanitation Community Based (WSS-CB) technologies by setting a bibliometric analysis based on a publication dataset drawn from Thomson ISI Web of Knowledge Science Citation Index, Web of Science, covering 1998 through 2008. Trends and patterns in relation to productivity, collaboration and research topics are identified. I find that Northern countries are the most active ones postponing Southern nations to a secondary role. In terms of collaboration, however Northern countries perform well, they mostly team up with equals; North-South seems not to be high priority for them. With regard to research topics, Southern R&D concerns do not represent a major share of Northern R&D, though lately an upward trend is noted. The article is organized as follows: Section 2 describes the Community-Based/Community Management (CB/CM) framework; Section 3, methods to be used; Section 4, results and analysis; and Section 5, conclusions and recommendations.

II. Community Based/Community Management

However international efforts, WSS still remains as an acute question in the developing world. Although unserved settlements have decreased during the last 30-40 years, WSS absolute numbers have slightly lowered and even in some

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cases increase [2]. What are the causes behind such delay? A quick answer is funding. The Global Water Partnership's Framework to Action deems in $30 billion per year the amount of funding needed to supply safe drinking water and basic sanitation to the world's population, a significant increase from its previous appraisal of $14 million done in 2000 [3]. Nevertheless, causes may go beyond funding. Non-consideration of local context may have hindered seriously the odds of success of previously proposed solutions, therefore in light of centralized solutions failure new bottom-up approaches have come up [4].

CB/CM refers to a bottom-up form of community participation in which communities make the final decision on design, planning, and implementation, and are responsible for running Operation and Maintenance (O&M) [5,6]. Solutions are defined as involving decentralized decision-making, community ownership, locally-oriented technology, and locally sustainable business and financial models [7,8]. However, success is constrained by a set of factors. As long as rules of the game, access to information, and support channels are rightly set, grass roots participation becomes feasible and fruitful, otherwise communities are unable to take over as service providers [6].

CB/CM did not emerge from nowhere. As a matter of fact, the approach has been part of the WSS international discussion for the last 30 years, with several applications already in operation such as Community Demand Driven (CDD), Community Led Total Sanitation (CLTS), Participatory Hygiene and Sanitation Transformation (PHAST), and Participatory Action Research (PAR) [4,6,9,10]. Why CB/CM? Reasons point to demography, as CB/CM is a better fit to address scattered or even inaccessible population; poverty, as poor settlements are more willing to manage their own systems, whereas richer ones just buy into an existing one; flexibility, as "one size fits all" solutions are not able to cover the wide variety of water use that particularly rural communities draw upon, therefore tailor-made solutions are more likely to emerge as CB/CM outcome; and finally empowerment, granting communities with new skills and decision-making power makes them stronger, more cohesive, and more able to demand their own rights [4].

As previous development methodologies, CB/CM brings along intensive discussions on what its benefits and limitations are. Among the former, scholars cite CB/CM's higher sustainability resulting from the community's involvement in funding and O&M; higher efficiency and effectiveness out of CB/CM's higher accountability; higher inclusion by involving those in vulnerable positions in designing their own solutions; higher empowerment of those with no voice resulting in new community-governance able to manage local resources; more people going out of poverty as scaling up becomes an easier process, and the formation of new multilevel social partnership [6,11,12].

Nevertheless, CB/CM has not been exempted from critics. Ref [12] , an analysis of World Bank-CB projects in Central Asia, notices that top-down orientation has not been left behind as projects are still guided by the Bank at the request of national governments, not of local communities; plus, what should be mutually beneficial partnerships are not always so as donors are doubtful to leave decision-making on local actors; and further strain on the already limited budgets of those in need merges with new imposed fees. Ref [4] states that communities cannot work on their own as earlier CB/CM champions may have promoted, their motivation and capacities must be complemented by external agents coming from government, civil society, and donors; communities require outside support to ensure sustainability and increase coverage.

III. Methods

A. Framework

I propose to use a framework based on three factors: productivity, collaboration, and research topics. The evolution through time of each factor is reviewed in order to figure out what trends have ruled them during the period under review. In terms of productivity, I determine WSS-CB global performance that is the total number of paper published, plus its country distribution. Switches on agents' productivity are noticed by comparing countries timing patterns. In relation to collaboration, analyses refer to both the whole period and yearly evolution with emphasis on diverging behavior that countries may have over time. The research topics analysis focuses on keywords cited by authors and their evolution through time to determine whether developed countries are getting involved in actual developing countries' problems. Furthermore, countries are grouped using cross-correlation maps to explore not only what research areas countries are working on the most yet who collaborate with whom in specific fields.

B. Search Strategy

Data is gathered using a Boolean search strategy consisting of two main bodies: a first macro one in relation to WSS-R&D records, and a second one referring to CB-technologies. The first body includes three basic concepts -"water supply", "sanitation", and "water quality"- out of Cozzens and Catalan methodology [13]. Reference [2] groups into 11 categories 61 proven, emerging, and blue skies water supply/sanitation/hygiene technologies. Among the 11 categories those not being part of my research goal were left off; plus, some were renamed as after an iterative process rewording them resulted in a better fit. Therefore, the first macro body ended up as follows:

"water supply" OR sanitation OR "water quality" OR "water treatment" OR "water sources" OR "water storage" OR "water delivery" OR "excreta disposal"

In regard to the CB-technologies body, I concentrate on the 43 technologies still on the list after leaving off those not related with my research goal. I mixed concepts related to those technologies such as "rainwater", "roofwater", "pump",

"coagulation", sedimentation", "desalination", "disinfection", "latrine", "stormwater" and "wastewater", with terms pointing to more specific community-based applications. Therefore the final search strategy was:

("water supply" OR "water quality" OR "water treatment" OR "water sources" OR "water storage" OR "water delivery" OR sanitation) AND TS=(((rainwater OR roofwater) AND (catchment OR storage OR harvesting)) OR (handpump OR pump AND (solar OR wind OR rope)) OR (coagul* AND seed*) OR (sedimentation AND (communit* OR village OR rural OR tank)) OR ((((desalination AND (distillation OR "reverse osmosis" OR electrodialysis)) OR (disinfection AND (ultraviolet OR UV OR chlorination OR ozone OR solar)) OR filt* or drilling) AND (communit* OR village OR rural OR "scale up")) OR (removal AND arsenic) OR latrine* OR "septic tanks" OR condom* OR (stormwater OR (wastewater NOT indus*)) AND disposal))

Once the SCI dataset was set, we used a text mining software in order to analyze and group the data according to the criteria mentioned above.

IV. Results

A. Productivity

The dataset resulting from the application of the search strategy gathered 1,231 records for the period from 1998 to 2008. An upward trend is noticed with an increase on the marginal growth rate during the last four years, period during which more than 55 percent of the articles were published (see Fig. 1). Timing of such pattern may be explained as a lagging effect of the MDGs enactment, which may have fueled WSS R&D efforts thereby increasing publishing rates.

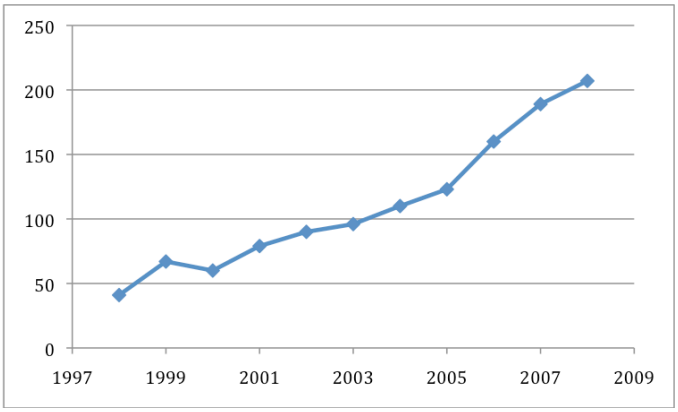

Fig. 1: Number of articles publshed 1998-2008
Source: Own author from WOS-SCI

In terms of country, 77 percent of the articles were published by scholars based at organizations in developed countries. North America, Europe and Asia contribute with 86 percent of articles, whereas Southern regions provide marginal shares: 6 percent Africa and 4 percent Latin America (see Fig 2). Although their productivity may be not significant at global level, it is worth noting two points: Africa and Latin America shares are higher than normal and Africa outperforms Latin America[1]. The data give some insights. Though Brazil is the most productive country among Latin American and African nations, there is no replication among its neighors. On the other hand, African countries that may have been thought of as not able neither to fund R&D nor to publish are among those publishing, that is Africa's productivity is not limited to South Africa and Kenya.

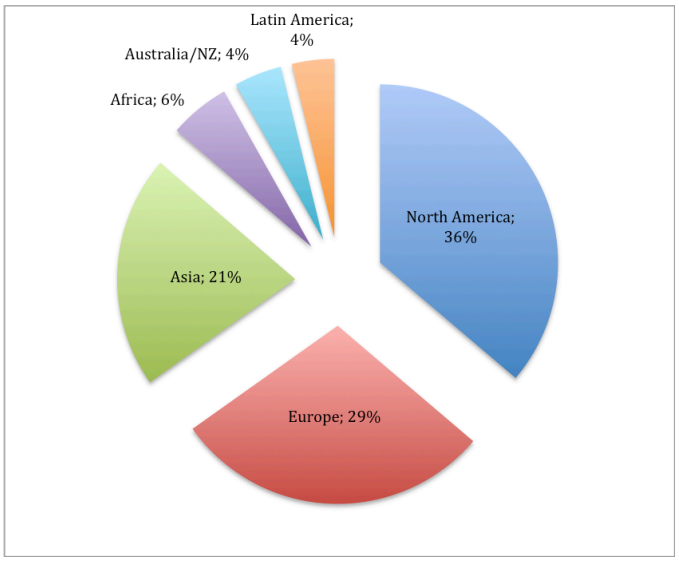

Fig. 2 Publications by regions
Source: Own author from WOS-SCI

In relation to how countries' publishing productivity has timely evolved, the US tops the list during the whole period (see Fig. 3). The UK, Canada, Germany, Japan, Australia, and France are developed countries on the top 10 of the list. Only two developing countries make the top 10: China and India whose performances have had a boost during the last four years growing at marginal rates of 41.36 percent and 85.36 percent, respectively, higher than the US and Europe. Although China's and India's fast growing rates are worth noting, Bangladesh making the top 20 and outperforming countries such as Brazil, South Africa, and even some wealthy nations comes up as noticeable fact. Arsenic pollution, a well know national problem, has led Bangladesh to strengthen its R&D capacity thereby to increase its publishing productivity, however severe budget restrictions.

In terms of organizations, I concentrated on the Top30 with 27 out 30 being based on a developed country. The US is the country with the highest number of organizations on the list (13) trailed by Canada (4), and China (2). Germany, France, Australia, Singapore, Greece, Belgium, Sweden, Japan, and India all placed one institution on the list. Four of the Top5 organizations are US-based, 2 public ones –the Environmental Protection Agency (EPA) and the Center for Diseases Control

[1] Africa amounts for 1.8 percent of global publications, whereas Latin America for 3.5 percent during the 2000-2004 period [14]

(CDC)- and 2 universities –Colorado State University and University of North Carolina. It is worth mentioning that 24 of the organizations on the Top30 are universities.

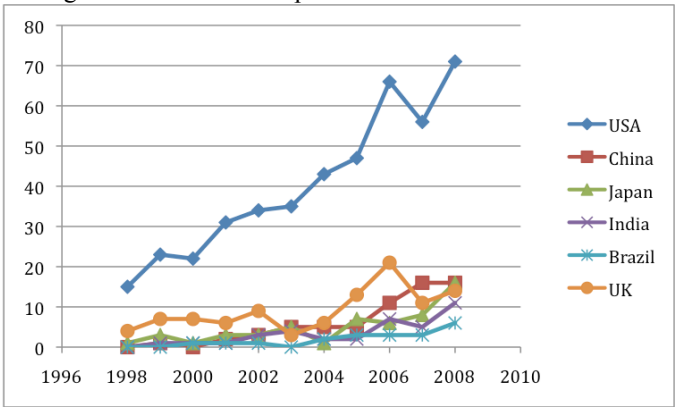

Fig. 3 Publications by country
Source: Own author from WOS-SCI

B. *Collaboration*

I analyze collaboration in terms of numbers of authors and organizations per article and at country level particularly regarding North-South collaboration. With regard to authors, the whole period distribution is relatively homogenous, with 49.88 percent of the articles having more than 3 authors. However, collaboration patterns have evolved over time. In 1998, papers including more than 3 authors amounted only for 34.15 percent, whereas in 1998 51.69 percent of the articles included more than 3 scholars teaming up (see Fig. 4).

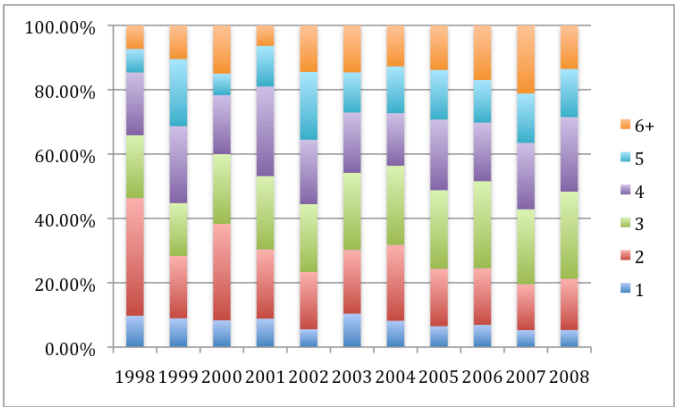

Fig. 4 Number of auhors per publication
Source: Own author from WOS-SCI

At organization level collaboration, though not performing as good as at author level, improves. Taking into account the whole period, 53.89 percent of the articles involve authors based on more than one organization, with the indicator going from 39.02 percent in 1998 to 62.32. percent in 2008. (see Fig. 5) Overall more authors and organizations are collaborating, with scholars increasingly reaching out to colleagues based on other organizations.

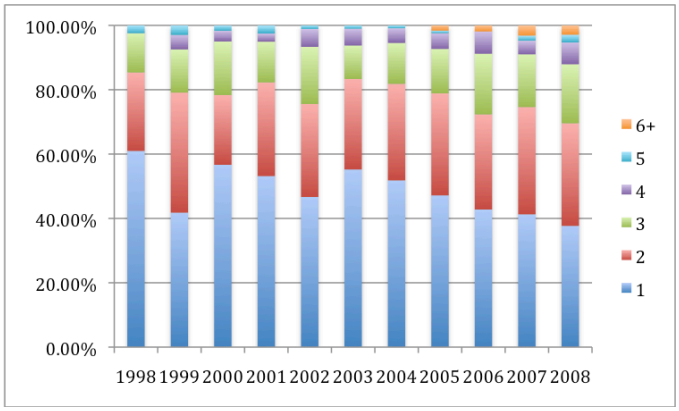

Fig. 5 Number of organizations per publication
Source: Own author from WOS-SCI

In regard to country level mapping collaboration sheds light on what patterns have been ruling during the period analyzed (see Fig 6). The map shows us that collaboration is not limited to North-North patterns as the US and some European countries seem to be active collaborators of Southern nations. However, quantitative indicators to explore whether North-South collaboration is strong may improve the analysis.

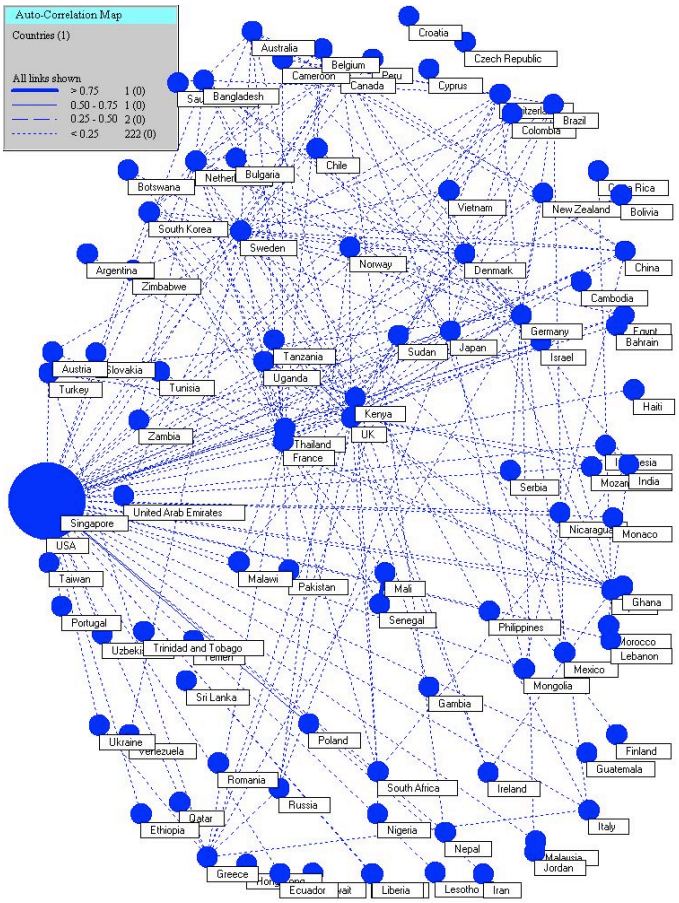

Fig. 6 Collaboration among Top30 countries
Source: Own author from WOS-SCI

To analyze North-South collaboration, I group each country on the list under one of two categories: either developed or developing country. It turns out that the number North-South

collaboration has consistently increased going from 0 in 1998 to 26 in 2008 amounting for 154 for the whole period. However, the number is not impressive vis a vis the number of papers authored by scholars based on developed nations, 1,039 records, resulting in a minimal 0.148 developing country collaboration per paper, that is *per each paper written by Northern scholars there is 14.8 percent likelihood that such paper includes at least one collaboration with a colleague based on a developing nation*. To achieve a more thorough analysis I concentrated on those papers including North-South collaboration and categorized developing countries in three categories: Africa, Latin America, and Asia (only developing countries) noting that most of those collaborations involved Asian countries and African countries, 43.75 and 35.42 percent respectively. Nevertheless, the patterns has been changing as during the first half of the period African countries were the ones that developed nations collaborate with the most among developing countries, selection that moved to Asian countries, particularly China and India, during the second half (see Fig. 7).

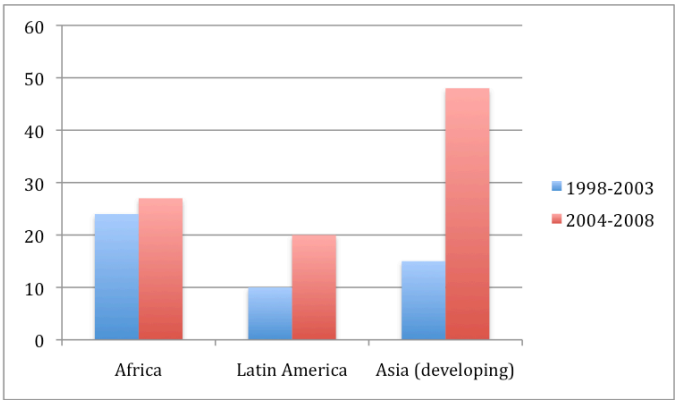

Fig. 7 Number of North South collaboration per region
Source: Own author from WOS-SCI

To consider whether wealthiest nations behave alike in terms of North-South collaboration I split them in two groups: the United States and European countries. With regard to the United States, over 444 papers, 50 collaborations with developing countries occur, therefore the likelihood that a paper authored by an US scholar includes at least one scholar based on a developing country is 11.29 percent. The US mostly collaborated with Asian nations, though, as the previous case, African nations were leading as US collaborators during the first half of the period until Asian nations took off during the second half (see Fig. 8).

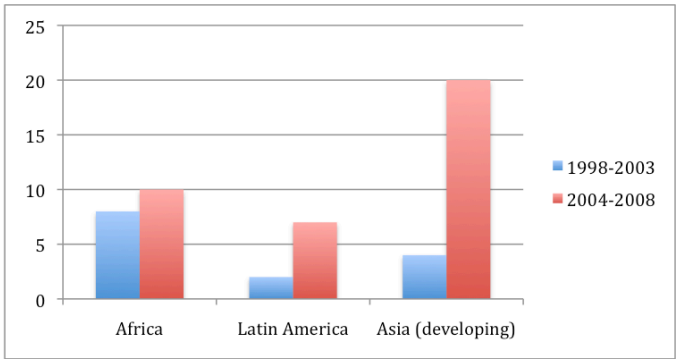

Fig. 8 Number of US-Developing Countries collaboration per region
Source: Own author from WOS-SCI

European countries perform better than the US as 76 collaborations with developing countries are noted among their 412 articles that is there is a 18.45 percent likelihood that a paper authored by an European scholars involved collaboration with at least one developing country's scholar. However, it should be noticed that the US has been outperforming European countries regarding collaboration with Southern nations during the last two years leaving behind previous low performances. In relation to who are European countries collaborating with, the trend is similar than the US and developed nations that is African nations were the ones that Europe collaborated with the most during the first half, turning that position to Asian ones during the last years (see Fig. 9). Nevertheless there is a point to be made. Collaboration with African countries though lower than with Asian countries keep growing during the second half in all case except European countries where it stagnates. Meanwhile, collaboration with Asia and Latin America grows sevenfold and threefold, respectively.

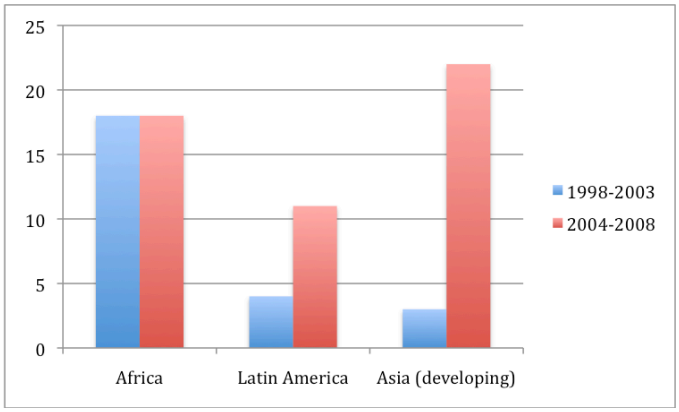

Fig. 9 Number of Europe-Developing Countries collaboration per region
Source: Own author from WOS-SCI

B. Research Topics

Thus far I note that albeit North South collaboration has increased is not significant for wealthy countries. However, collaboration analysis should not be limited to number of country co-occurrences per paper. Whether an article authored by Northern scholars addresses research topics regarding problem solving in the South, still remains

unanswered. In response to such concern I first provide a cross-correlation map grouping countries per research topic (see Fig. 10). To identify research topics I use the ISI-WOS "Keyword plus" field. The map shows a central cluster of developed countries dealing with topics such as water treatment, filtration and disinfection technologies, whereas developing nations, scattered all over the map, focus on health and sanitation issues particularly for children. Therefore, I noted that collaboration for developed countries neither include a significant share of developing nations nor concentrated on topics of interest of scholars in the developing world.

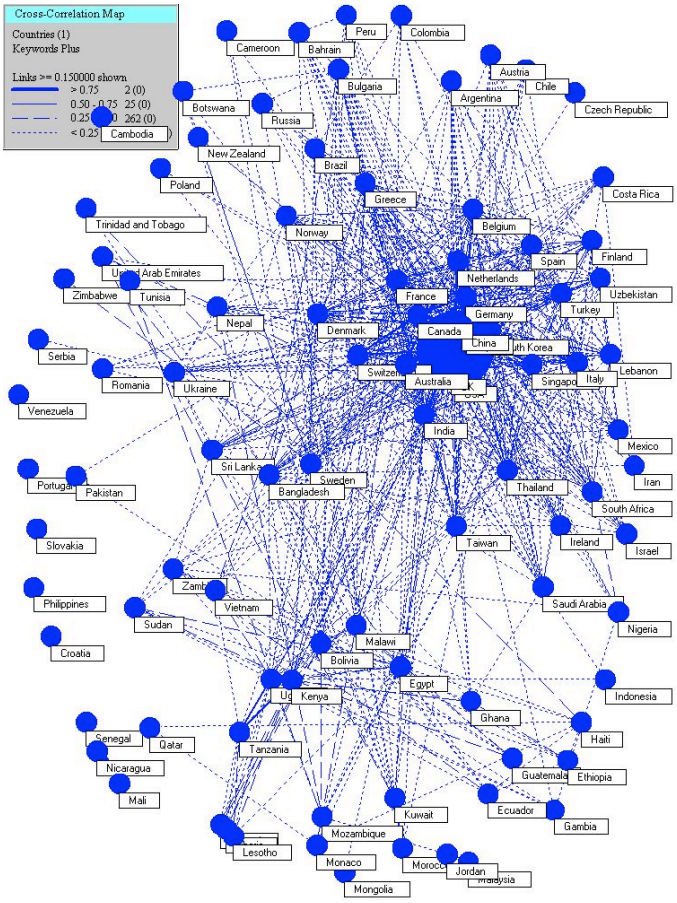

Fig. 10 Cross-correlation map: Country/Keywords
Source: Own author from WOS-SCI

To confirm my preliminary observation that developed nations do not get highly involved in research topics taken on by scholars from the South, I drew the Top40 research topics cited by developing country's authors then checked how many times those forty topics were cited by developed country's authors. It turns out that the latter cited 1,064 times the developing country's Top40 research topics during the whole period. However, what might be seem high at first sight turn out not to be so, once I calculated how much such number represents over the number of times any research topic is cited by developed country's authors (6,293): 16.91 percent, that is the likelihood that developed country's scholars cited at least one of the developing country's Top40 research topics is 16.91 percent. When splitting the whole period into two half, 1998-2003 and 2004-2008, to analyze whether the pattern has evolved over time, an increase is noted going from 15.75 to 17.73 percent.

V. Conclusion

As expected, productivity increased steadily during the period covered, primarily under developed countries lead. However developing countries are secondary actors, it is worth noting that they outperformed themselves in regard to their global performances. African countries must be highlighted, as they are able not only to outperform themselves yet also Latin American countries regularly ahead of them in publication productivity.

With regard to collaboration, mapping shows an active sector, with Northern and Southern countries collaborating with each other. Nevertheless, collaboration with Southern countries does not represent a significant share of Northern countries' performance. In terms of developed countries' partners, African countries were the ones on the top of the list during the first half turning the lead to Asian countries in recent years. Furthermore, developed and developing countries main concerns are not alike, though the former have been increasingly paying more attention to the interest of the latter during the last years.

Overall, though not as fast as it may be required, North South collaboration is increasing in terms of number of collaborations and more importantly of Northern countries' involvement in Southern countries issues. Future research will be needed to explore whether those patterns come up in response to public policies aimed to provide new WSS solutions to those in need by means of either capacity building processes in developing countries or increasing North South collaboration.

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